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[ijirset@gmail.com](mailto:ijirset@gmail.com)

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# Experimental Investigation on Properties of M20 Grade Concrete using 100% Replacement of River Sand with Crushed Sand

Ganesh C. Rasankar, V.M. Bogar

P.G. Student, Department of Applied Mechanics, Government College of Engineering, Karad, Maharashtra India<sup>1</sup>

Assistant Professor, Department of Applied Mechanics, Government College of Engineering, Karad, Maharashtra India<sup>2</sup>

**ABSTRACT:** In many regions of India, crushed sand (MS) has arisen as an alternative fine aggregate to river sand (RS). Given that CS is an aggregate made from rock boulders, its particle size, Surface properties and absorption varies from aggregate made of river sand, which is manufactured in accordance with geology and the regional weathering process. Broken sand has more angular particles and a rougher surface compared to actual river sand, and flatter face. It has become the need of the time to investigate the other alternative to natural sand as the demand supply ratio of natural sand cannot be fulfilled, which has further led to some ecological imbalances in the environment. The alternative to natural sand is manufactured sand (M-sand). Disposing of industrial by product has also become a tedious work, if these by product are not dispose properly, they cause environmental hazards. The lack of high-quality natural river sand has led to an increase in the use of manufactured sand (M-sand). In order to obtain great quality and regular gradation, manufactured sand is often made by feeding stones of various sizes through VSI crushers. The m-sand created by the aforementioned technique is typically more angular and has a rougher surface texture. Under clause 20, this M-sand has a clear definition in IS 383-1970. After being crushed, M-sand is washed away in a sand trap to get rid of the fines. This washing facility lowers the rate at which M-sand absorbs water. In this experimental research of 100% use of manufactured sand has been done. Concrete of grade M20 was casted from OPC 43 grade cement. The test was conducted on 28days, 56days, & 90days and comparative study has been performed using test results of Compressive Test, Split Tensile Test, Flexure Test, Shear Test, Acid Bath Test, Permeability Test, Rapid Chloride penetration Test (RCPT), between samples casted using 100% natural sand (M1), 100% manufactured sand (M2). The result showed that the manufactured sand gives better result in flexure strength, resistance against chloride ion penetration, and acid attack.

**KEYWORDS:** Natural sand, crushed sand (Manufactured Sand), Rapid chloride penetration test, Acid Bath, Compression Test, Split Tensile Test.

## I. INTRODUCTION

The potential use of crushed sand, which is made by crushing rocks, in concrete has been looked into by many parties. Crushed sand has been determined to be more affordable and environmentally friendly than river sand that naturally occurs. Crushed sand is more advantageous than river sand in terms of processing costs because it is less expensive. Astonishing, cubical, angular, rough-textured, and smooth-surfaced crushed sand particles are possible. To display appropriate workability, crushed sand concrete may need more cement than is now present. The inclusion of crushed sand in concrete results in superior workability, strength development, and durability attributes due to the presence of micro-fine particles in the sand. crushed sand has been used to create concrete that is strong and long-lasting. The crushed sand has a considerable impact on the water consumption and the workability of the mortar due to the high fines concentration that is present. Standard tests may not always be able to evaluate other sand characteristics such mineralogy, particle shape, and surface roughness. However, they may have a significant impact on overall performance. Therefore, in-depth analyses of the mechanical and durability behavior of concrete with C-sand replacement are required. The desired grade (zone II) and fineness modulus of (2.4 to 3.1) can be accomplished by the washing and screening procedure. As a result, correctly processed M-sand can be utilized to produce concrete with



improved mechanical and durability attributes due to a better bond than river sand. Sand’s particle shape is determined by its history of development. Because of the cumulative effect of several collisions and abrasion, natural sand tends to be rounded. Rock crushing produces manufactured sand, which is made up of grains with unique particle morphologies that rely on the composition of the parent rock, the fracture mode coordination number during crushing, and the reduction ratio.

## II. MATERIAL AND METHODS

The natural sand used in the mix was obtained from the Krishna River basin. The crushed sand used was obtained from Vertical Shaft Impact (VSI) crusher. The parent rock in the manufacturing of crushed sand was basalt. The same rock was used in the manufacturing of normal coarse aggregate used in the mix. Ordinary Portland Cement (OPC) conforming to IS 8112: 1989 [9] was used in all mixes with standard consistency of 34 %, Initial Setting Time (IST) of 40 minutes, Final Setting Time (FST) of 390 minutes Fineness of 4%.

1. Particle size distribution: This is the most important property of Fine aggregate as it affects the particle packing. After conducting a sieve analysis of natural sand and crushed sand, the particle size distribution curve obtained is as shown in fig. 1
2. Specific gravity: The specific gravity of aggregate was found using the pycnometer method as specified in IS 2386: 1963 (Part III) [10]. After carrying out the standard procedure, the specific gravity of natural sand, crushed sand, normal aggregates were found as given in table 1.
3. Water absorption: Water absorption of aggregate is an important property in the concrete mix design. The water absorption of natural sand, crushed sand, normal aggregate was found as per IS 2386: 1963 (Part III) [10], and the results obtained after the test are shown in table 1.
4. Silt content: The % silt content of natural sand was determined as per IS 2386: 1963 (Part II) [11] and was found to be 4.05%.
5. Crushing, Impact, and Abrasion value: The Crushing value, Impact value, and abrasion value are the most important mechanical properties in accessing coarse aggregate quality. The test on normal aggregate was conducted as per IS 2386: 1963 (Part IV) [12], and the results of the test are shown in table 2.

**Properties of fresh concrete:** For preparing the concrete, the coarse aggregate passing through a 20mm IS sieve and retained on a 10 mm IS sieve were used. The natural sand and crushed sand used were passed through 4.75 mm and retained on 150 microns IS sieve. While mixing ingredients for the preparation of concrete normal weigh batching was done for mixes M1, M2 and M3. The mixing is done in 2 stages, firstly the mixing is done in dry state and secondly mixing is wet mixing after addition of water. After the production of concrete, the workability of fresh concrete was checked using the slump cone apparatus. The workability of concrete mix M1 was found to be 100mm while that of mix M2 and mix M3 was found to be 90mm and 100mm respectively.

Figure.1. Particle Size Distribution Curve

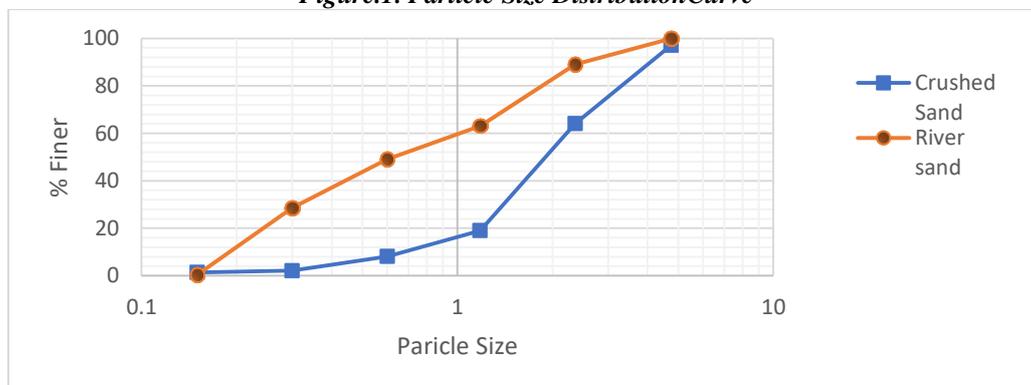




Table 01. Mechanical Properties of Coarse Aggregates

Properties	Normal Aggregate
Crushing Value	12.65
Impact Value	5.97
Abrasion Value	21.32

Table 02. Physical Properties of Fine and Coarse Aggregates

Properties	Natural sand	Crushed sand	Normal Aggregate
Specific Gravity	2.95	3.21	2.95
Water Absorption	3.1	1.43	0.7
Silt content(%)	4.05	-	-

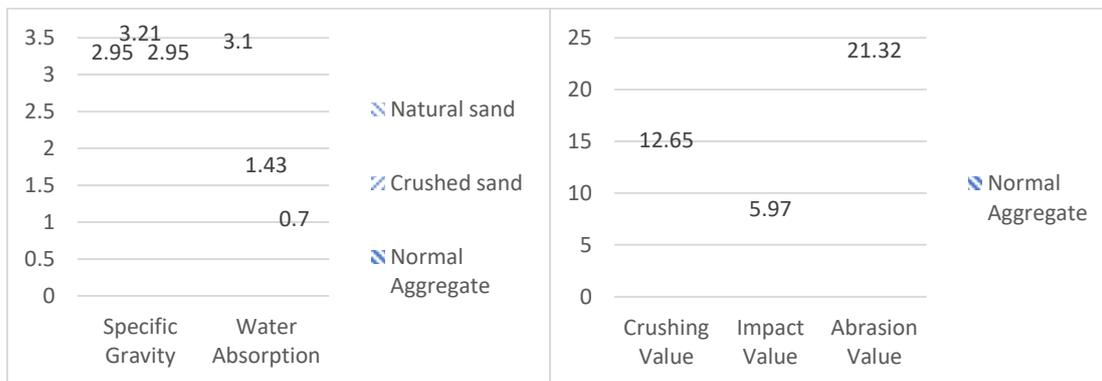
### III. RESULTS AND DISCUSSION

The specific gravity of natural sand was found to be 2.95 while that of crushed sand was found to be 3.21. As crushed sand is produced after crushing rock, the number of organic impurities present in the crushed sand is less. Due to this, the specific gravity of crushed sand is more as compared to natural sand. On the other hand, the specific gravity of natural coarse aggregate is 2.95.

In the case of natural sand, the water absorption was found to be 3.1% while that of crushed was found to be 1.3%. As stated earlier the percentage of silt and other organic impurities is almost zero in crushed sand, the percentage of water absorbed by it is less compared to natural sand.

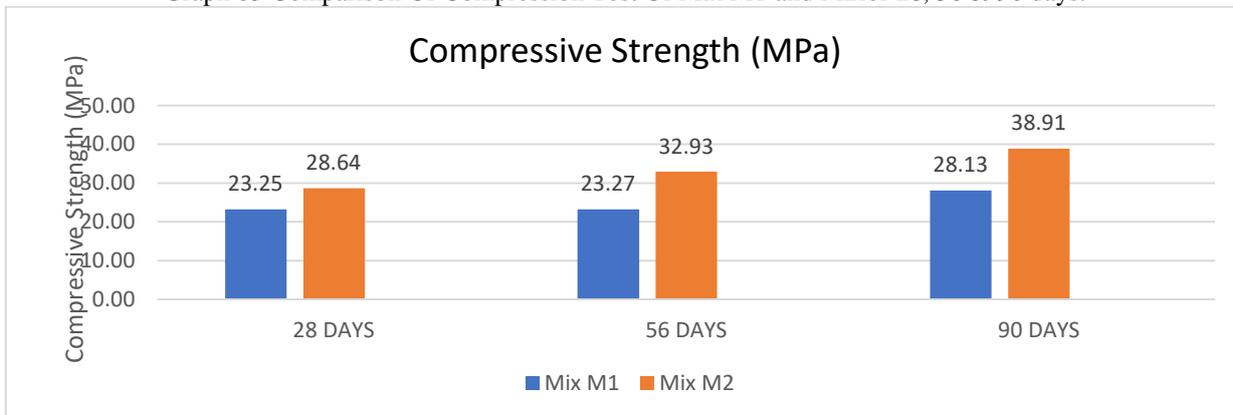


Graph 01. Comparison Of Physical Properties of Aggregate Graph 02. Comparison Of Mechanical Properties of Coarse Aggregate

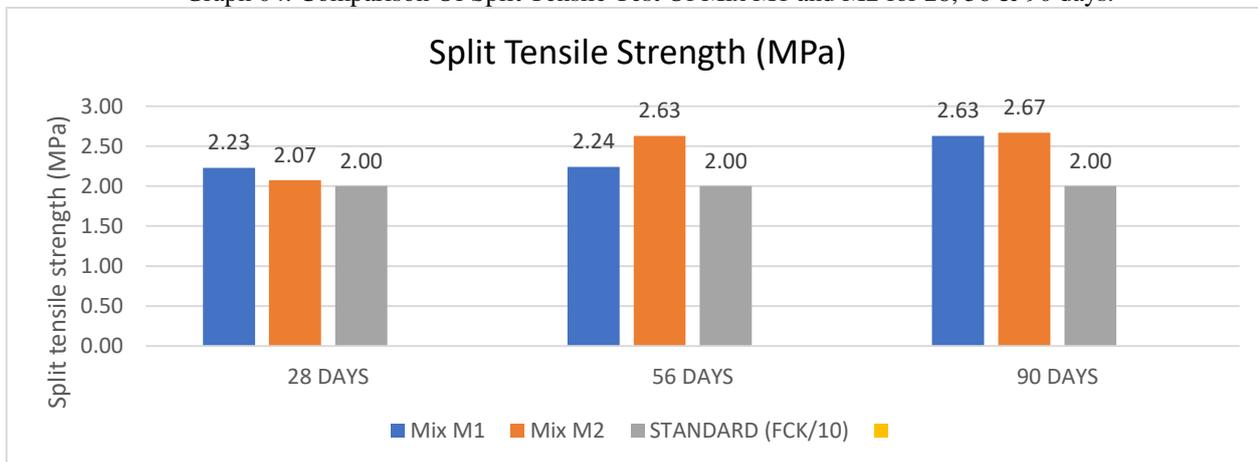


The workability of fresh concrete produced using natural sand and natural aggregate was 100mm, while that of crushed sand and natural aggregate was 90mm. The decrease in workability in concrete containing crushed sand was due to the presence of more angular particles. The natural sand contains spherical particles which enhances the ability of concrete to flow.

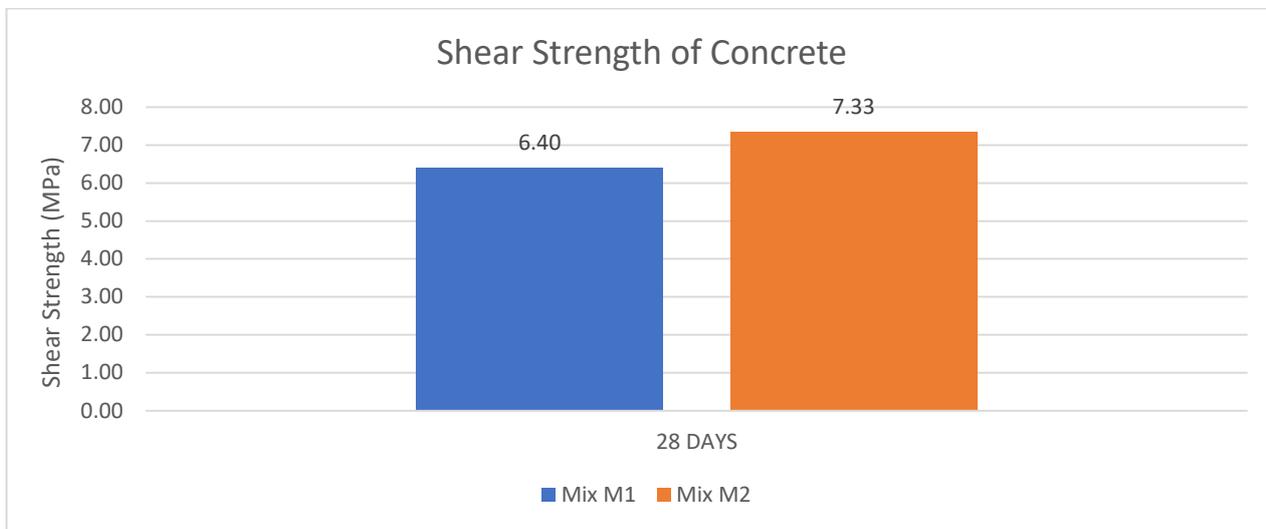
Graph 03 Comparison Of Compression Test Of Mix M1 and M2 for 28, 56 & 90 days.



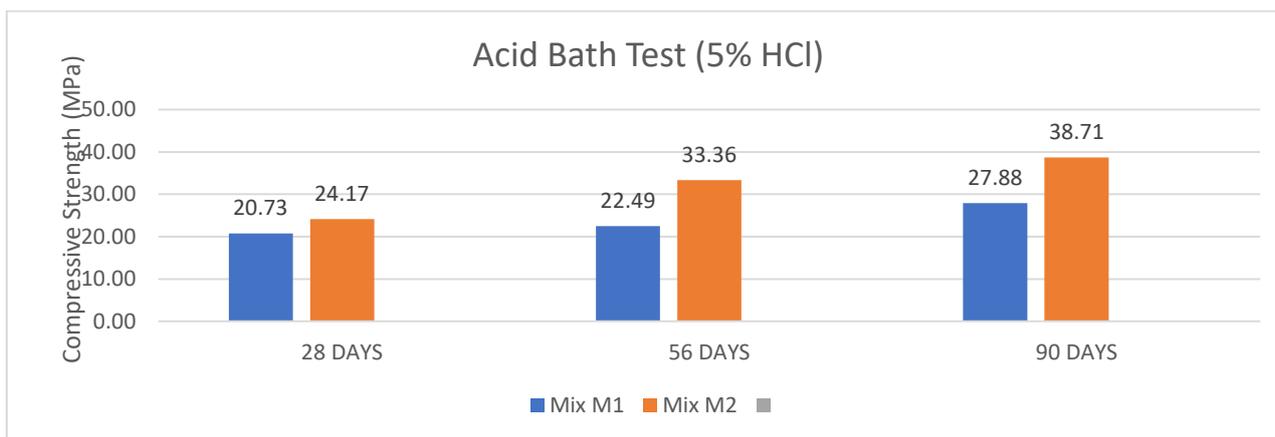
Graph 04. Comparison Of Split Tensile Test Of Mix M1 and M2 for 28, 56 & 90 days.



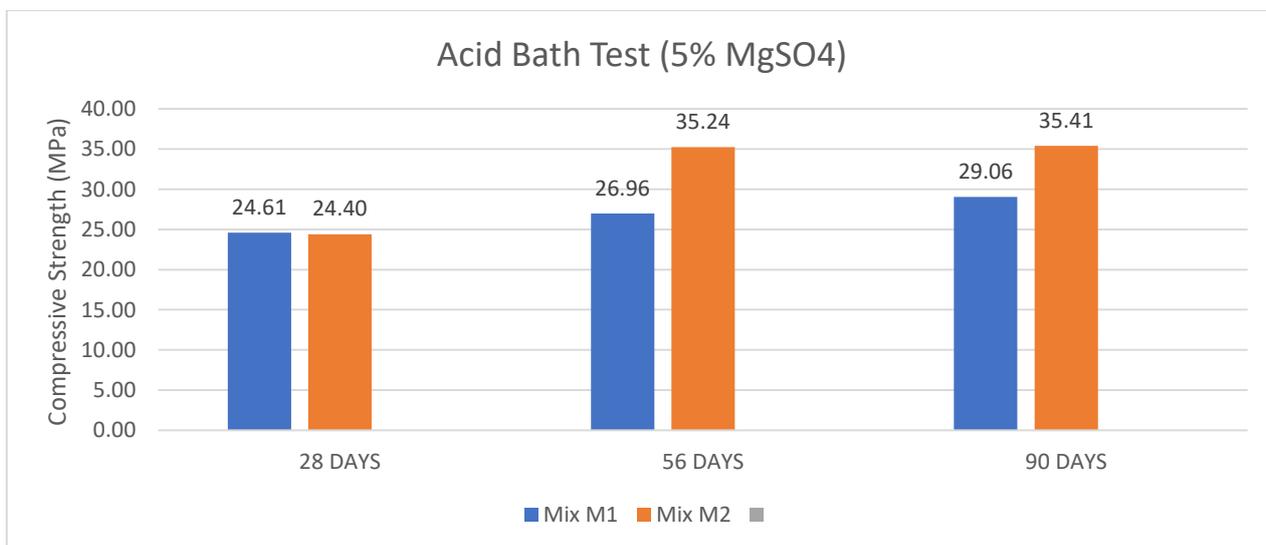
Graph 05. Comparison of Shear Strength of concrete.



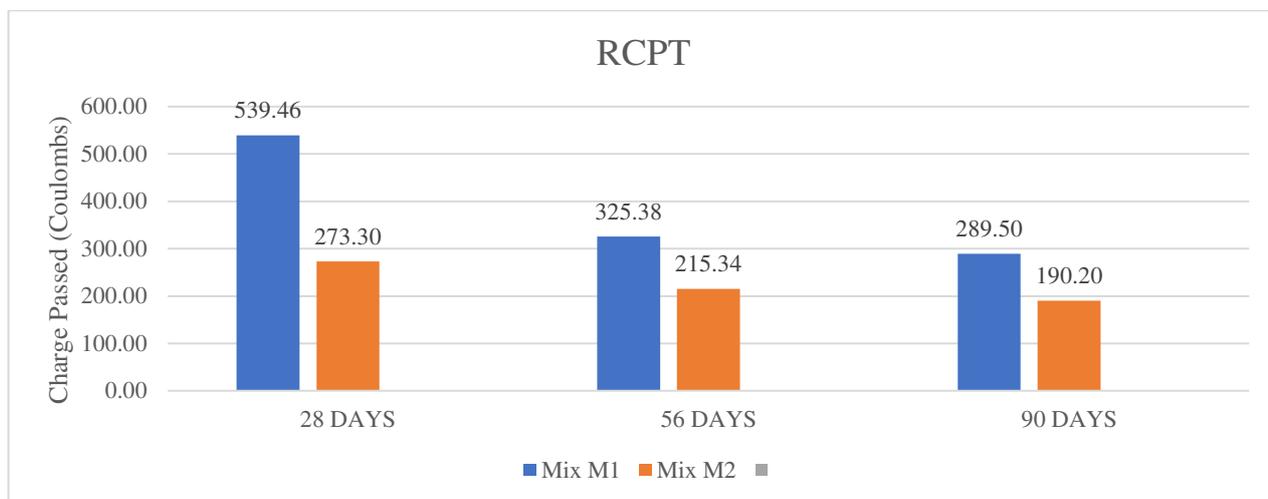
Graph 06. Comparison of Acid Bath Test (HCL Soln.) Of Mix M1 and M2 for 28, 56 & 90 days.



Graph 7. Comparison of Acid Bath Test (MgSO<sub>4</sub> Soln.) Of Mix M1 and M2 for 28, 56 & 90 days.



Graph 8. Comparison of Rapid Chloride Penetration Test of Mix M1 and M2 for 28, 56 & 90 days.



IV. CONCLUSION

- At 28 days, 56 days and 90 days for mix M1 the compressive strength was found to be 23.25 N/mm<sup>2</sup>, 23.27 N/mm<sup>2</sup>, and 28.13 N/mm<sup>2</sup> which is respectively 16.25%, 16.37% and 40.65% more than that of designed. Similarly, for mix M2 at 28 days, 56 days and 90 days the compressive strength was found to be 28.64 N/mm<sup>2</sup>, 32.93 N/mm<sup>2</sup>, and 38.91 N/mm<sup>2</sup> which is respectively 43.2%, 64.65% and 94.55% more than that of designed.
- At end of 28 days, mix M1, M2 showed 11.5%, 3.5% and more split tensile strength respectively than the standard value of 2 N/mm<sup>2</sup>. After 56 days of casting, mix M1, M2 showed 12%, 31.5%, more split tensile strength respectively than that of standard value. And similarly, after 90 days the percentage increase in mix M1, M2 were 31.5%, 33.5%, respectively.
- When cubes were immersed in 5% HCL, at 28 days, 56 days, and 90 days for mix M1 the compressive strength was found to be 20.73 N/mm<sup>2</sup>, 22.49 N/mm<sup>2</sup>, and 27.88 N/mm<sup>2</sup> which is respectively 3.65%, 12.45%, and 39.4% more than that of design. Similarly, for mix M2 at 28 days, 56 days, and 90 days the compressive strength was found to be 24.17 N/mm<sup>2</sup>, 33.36 N/mm<sup>2</sup>, and 38.71 N/mm<sup>2</sup> which is respectively 20.85%, 66.8% and 93.55% more than that of designed.
- When cubes were immersed in 5% HCL, at 28, 56, and 90 days mix M1 shows 0.69%, 0.81%, and 1.7% decrease weight respectively. While mix M2 showed 0.22%, 0.22% and 0.33% decrease in weight at 28, 56, and 90 days respectively.
- When cubes were immersed in 5% MgSO<sub>4</sub>, at 28 days, 56 days, and 90 days for mix M1 the compressive strength was found to be 24.61 N/mm<sup>2</sup>, 26.96 N/mm<sup>2</sup>, and 29.06 N/mm<sup>2</sup> which is respectively 23.05%, 34.8%, and 45.3% more than that of design. Similarly, for mix M2 at 28 days, 56 days, and 90 days the compressive strength was found to be 24.40 N/mm<sup>2</sup>, 35.26 N/mm<sup>2</sup>, and 35.41 N/mm<sup>2</sup> which is respectively 22%, 76.3% and 77.05% more than that of designed. And for mix M3 at 28 days, 56 days and 90 days the compressive strength was found to be 24.89 N/mm<sup>2</sup>, 25.81 N/mm<sup>2</sup>, and 28.26 N/mm<sup>2</sup> which is respectively 24.45%, 29.05% and 41.3% more than that of designed.
- When cubes were immersed in 5% MgSO<sub>4</sub>, at 28, 56, and 90 days mix M1 shows 0.3%, 0.3%, and 0.34% decrease weight respectively. While mix M2 showed 0 %, 0.1% and 0.1% decrease in weight at 28, 56, and 90 days respectively.
- In case of RCPT for mix M1, the chloride ion permeability was 539.46 coulombs, 325.38 coulombs, and 289.50 coulombs after 28, 56, and 90 days respectively. Similarly, for mix M2 the chloride ion permeability was 273.30 coulombs, 215.34 coulombs, 190.20 coulombs at the end of 28 and 90 days respectively.
- The Modulus of elasticity after 28days for manufactured sand was 25288.55 N/mm<sup>2</sup>.

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